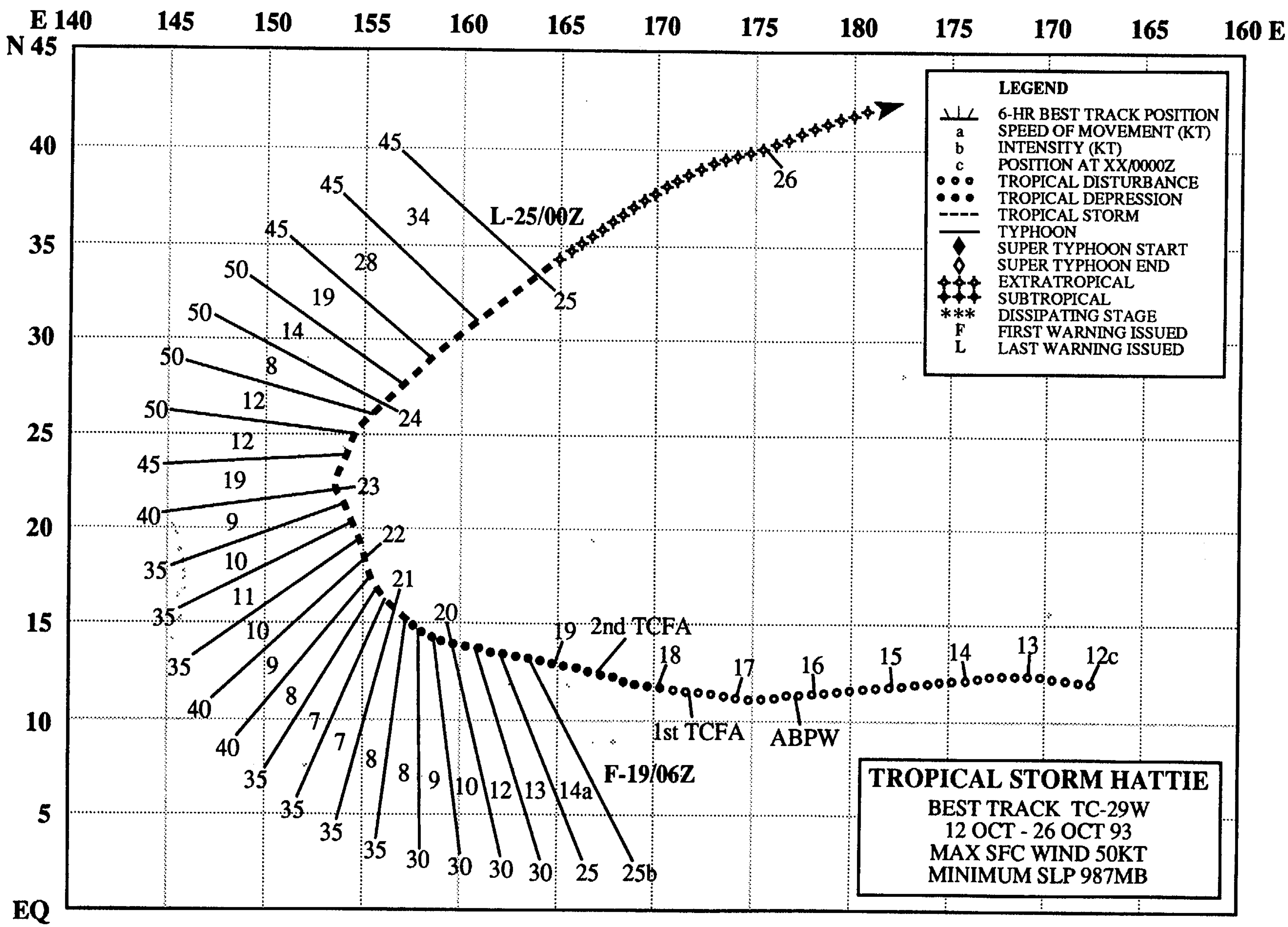
LEGEND
6-HR BEST TRACK POSITION
a SPEED OF MOVEMENT (KT)
b INTENSITY (KT)
c POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
SUBTROPICAL
*** DISSIPATING STAGE
F FIRST WARNING ISSUED
L LAST WARNING ISSUED
TROPICAL STORM HATTIE
BEST TRACK TC-29W
12 OCT - 26 OCT 93
MAX SFC WIND 50KT
MINIMUM SLP 987MB
L-25/00Z
F-19/06Z
2nd TCFA
1st TCFA
ABPW

# TROPICAL STORM HATTIE (29W)

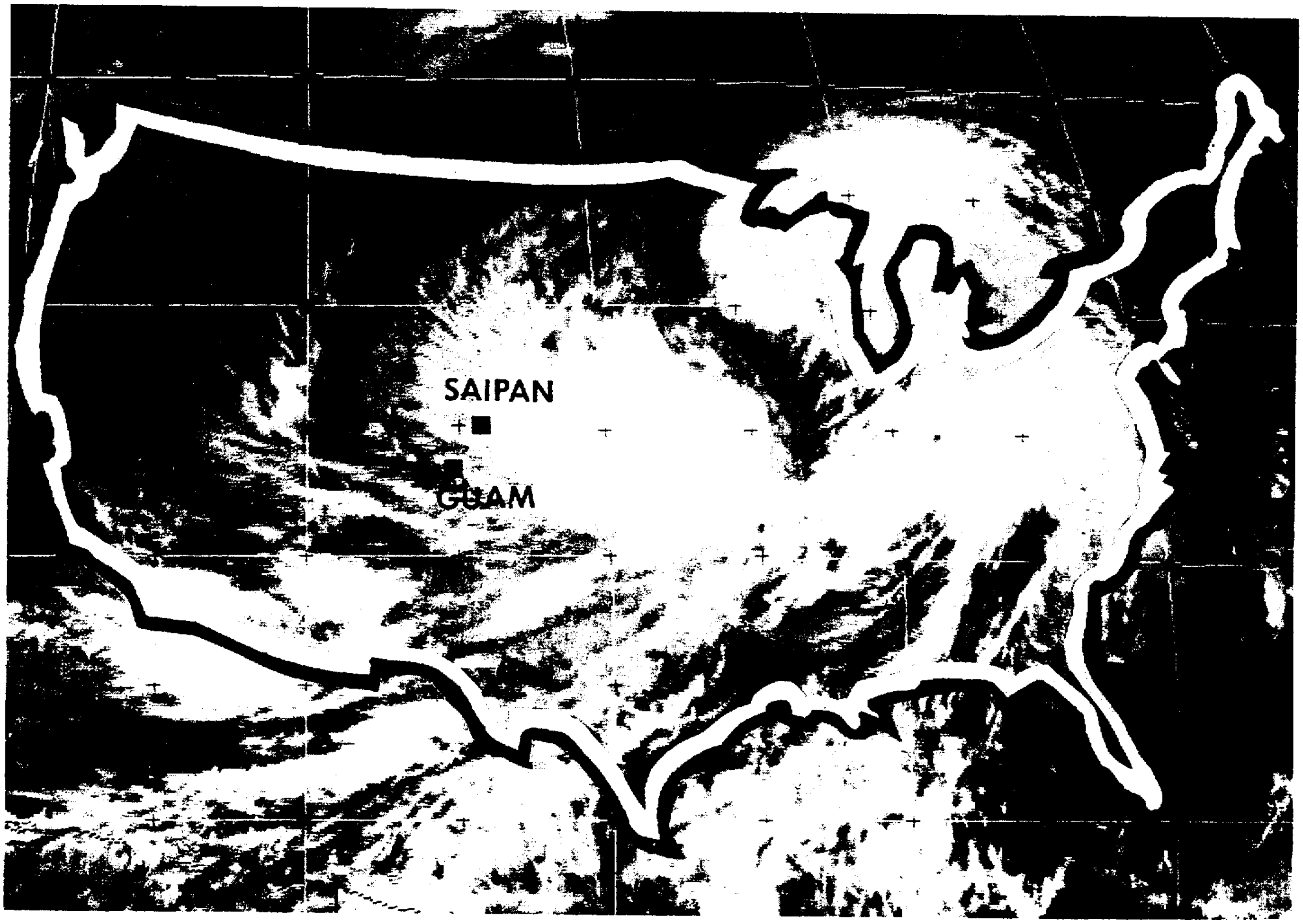


**Figure 3-29-1** An outline of the U.S. mainland superimposed (to-scale) upon an infrared image of Hattie (220030Z October infrared GMS imagery).

## I. HIGHLIGHTS

Hattie started as a large monsoon depression. Five Tropical Cyclone Formation Alerts were issued — three by the Central Pacific Hurricane Center (CPHC) and two by the JTWC — before the first warning was issued. The system was unique because of its cloud structure: a large 100-160 nm (200-300 km) diameter central area remained relatively cloud-free while convective cloud clusters were peppered throughout the periphery of the circulation in an area equal in size to the continental United States (see Figure 3-29-1).

## II. CHRONOLOGY OF EVENTS

October

160600Z - The tropical disturbance was first mentioned of the in the Significant Tropical Weather Advisory as a region of loosely organized convection associated with a large monsoon depression near the international date line.

171630Z - The first JTWC Tropical Cyclone Formation Alert (TCFA) issued was based upon an increase in convection and improved convective curvature.

181630Z - A second TCFA (fifth overall) followed after the system failed to intensify.
190600Z - The first warning was issued based upon numerous synoptic reports of 25 kt (13 m/sec) in a peripheral wind band encircling a large light-wind core.
201800Z - The upgrade to a tropical storm was based upon surface synoptic reports of winds up to 35 kt(13 m/sec) within the peripheral wind band.
250000Z - The final warning was issued on Hattie as it transitioned into an extratropical low.

## III. IMPACT

The island of Pohnpei in the eastern Caroline Islands reported minor damage to vegetation and structures.

## IV. DISCUSSION

From a diagnostic standpoint, Hattie was one of the most problematical tropical cyclones of 1993. Hattie evolved from a large monsoon depression which formed in the Marshall Islands during mid-October. A "monsoon depression" is distinguished from other types of tropical cyclones by the following characteristics (see also the definition in Appendix A):

1) a large-sized depression in the surface pressure field with a radius of the outermost closed isobar (ROCI) on the order of 300 nm (555 km);

2) extensive amounts of convective cloud elements loosely organized within the confines of the cyclonic vortex; however, the circulation center lacks a persistent convective feature that would lend itself to the Dvorak intensity analysis technique; and,

3) a wind field that features a large, 100-160 nm (200-300 km) diameter, light-wind core which is surrounded wholly, or in part, by bands of higher, 25-35 kt (13-18 m/sec) wind.

The monsoon depression which became Tropical Storm Hattie was large; a composite chart of its sea-level pressure was constructed from surface observations taken during the period 181200Z to 200000Z October (Figure 3-29-2). The ROCI during the composite period was 430 nm (800 km) north-south and 755 nm (1400 km) east-west. The cloud field associated with Hattie during the composite period exhibited a large core region which was relatively cloud free surrounded by extensive clusters and bands of deep cumulonimbus clouds. The structure of the wind field at this time featured a large core of relatively light wind (which was collocated with the relatively cloud-free core in the satellite image) surrounded by an extensive area of 25-30 kt (13-15 m/sec) wind outward for up to 540 nm (1000 km) clockwise from northwest to southwest.

Hattie presented two diagnostic problems to the JTWC. The first problem was that since it lacked persistent central convection, and the Dvorak technique for the estimation of tropical cyclone intensity from satellite imagery does not apply. Attempts were made, however, to apply the technique to one of several of Hattie's persistent peripheral cloud clusters. Finally, however, as Hattie turned northward, a distinct and centrally located low-level circulation center became apparent (Figure 3-29-3), and the Dvorak technique applied.

The second diagnostic problem was determining whether the disturbance (which was to become Hattie) was a monsoon depression or a monsoon gyre (see Appendix A for complete definitions of these terms and Figure 3-29-4). As a monsoon depression, the disturbance would be expected to evolve eventually into a conventional, but large, tropical cyclone. As a monsoon gyre, the disturbance would be expected to evolve into a large "fish-hook" shaped cloud band which would produce a series of small tropical cyclones. In retrospect, the option to go with the synoptic pattern as a monsoon depression was correct.

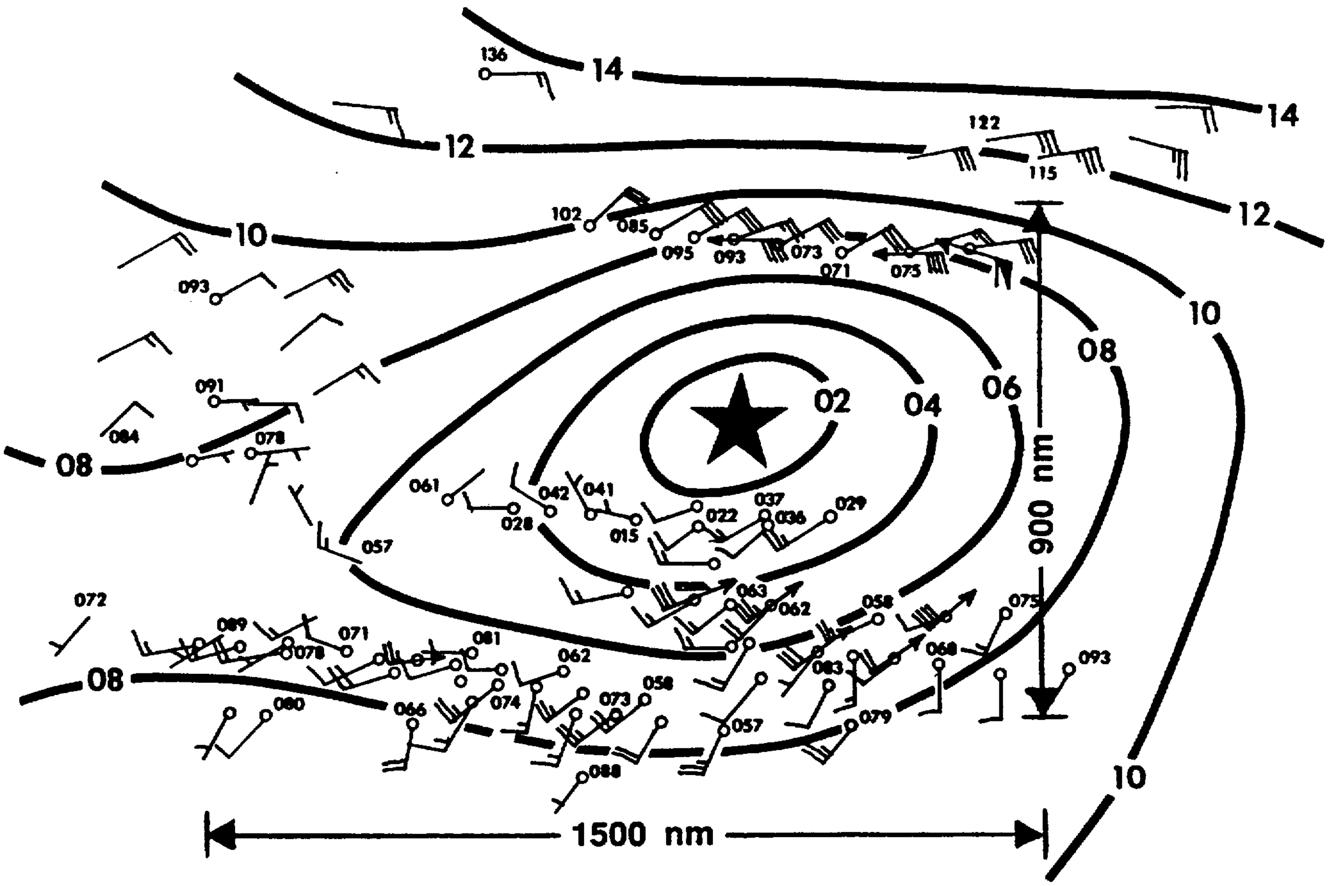


**Figure 3-29-2** Isobaric analysis of the sea-level pressure constructed from a composite of observations plotted with respect to the moving center of Hattie (large star). Contour interval is 2 mb, and data are for 181200Z - 200000Z.

In summary, the Dvorak technique shouldn't be applied to monsoon depressions. For the present, the intensity and areal extent of the peripheral winds must be obtained from conventional synoptic data or from cloud-drift winds. A Dvorak-type technique could be developed to address intensity estimation and wind distribution in the monsoon depression. Other spectral windows than the visual and infrared, such as the SSM/I, may be exploited. The differential diagnosis between "monsoon depression" and "monsoon gyre" is important for its forecast implications; and, in the case of Hattie, a careful analysis of the structural characteristics led to a useful diagnosis of the pre-Hattie disturbance as a monsoon depression.

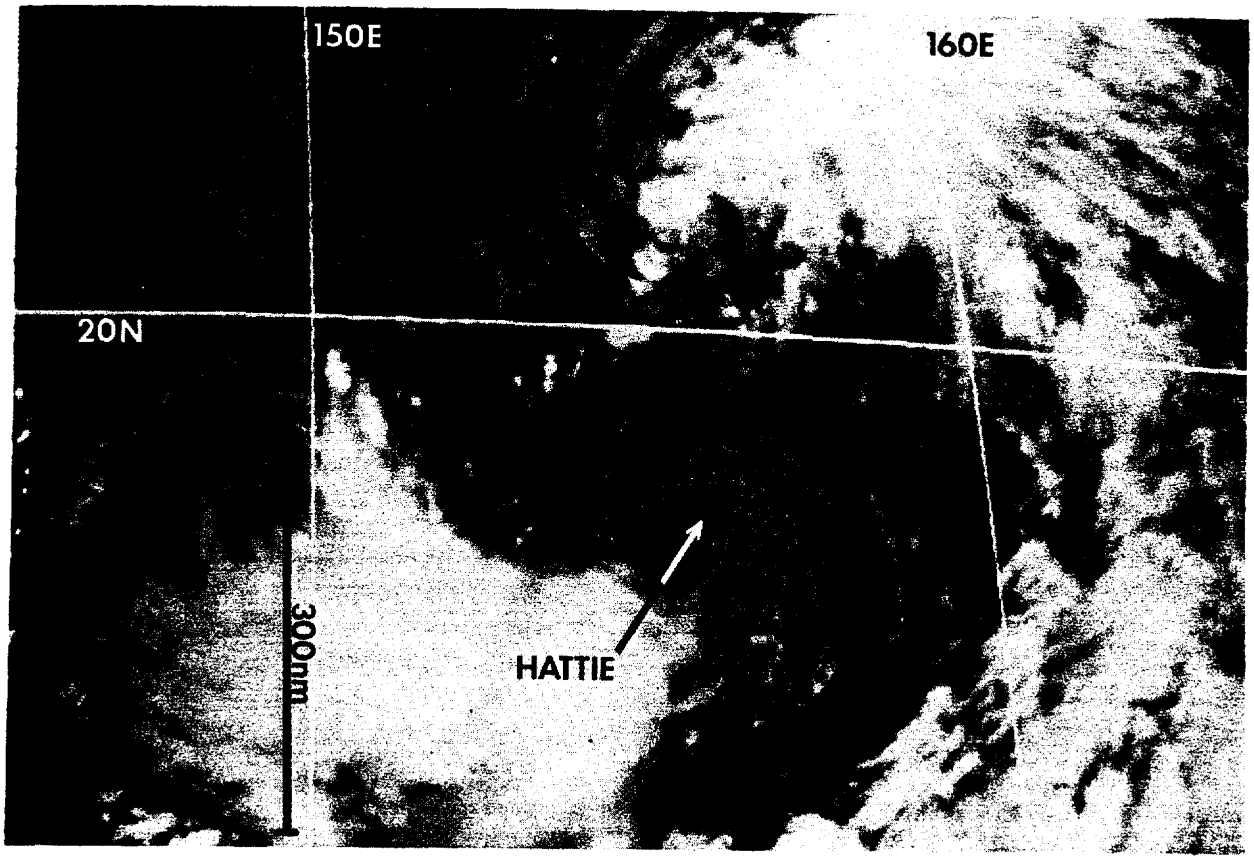


**Figure 3-29-3** Hattie's exposed low-level circulation center (LLCC) appears between two areas of extensive convective cloudiness (220031Z October multispectral visual/infrared GMS imagery).

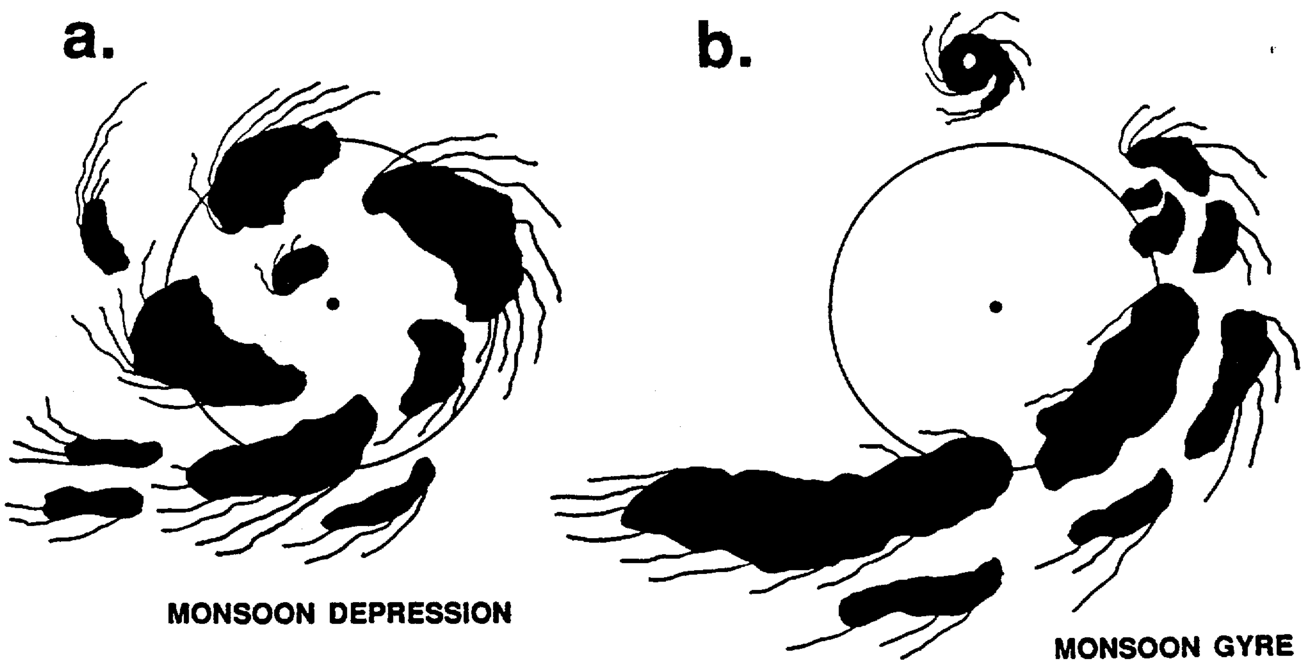


**Figure 3-29-4** Schematic illustration of the distribution of deep convective cloud and cirrus in: a) a monsoon depression, and b) a monsoon gyre. Black areas represent deep convection, and filaments indicate orientation of cirrus plumes. Circle enclosed area of lowest sea-level pressure and has a diameter of approximately 600 nm (1110 km). The black dot is the low-level circulation center.